Mineralogy and classification of Nagara iron meteorite

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Introduction: Iron meteorites are divided into two types: “magmatic” irons derived from metallic cores of protoplanets and “non-magmatic” irons formed by low-temperature small-scale partial melting of planetesimals related to primitive achondrites, and they provide important information about the material evolution from planetesimals to protoplanets. So far there were 50 meteorites found in Japan, including 8 iron meteorites. In February 2018, a new iron meteorite “Nagara” was approved by The Meteoritical Society and in this abstract we report its chemical compositions and corresponding chemical grouping.

Sample and methods: Nagara is a ca. 6.5 kg iron meteorite found at a chestnut yard in Gifu-City, Gifu Prefecture in 2012. The sample was brought at Gifu Shotoku Gakuen University in 2017 and then sent to University of Tokyo for chemical analysis. A chip weighing 55.8 g was cut from the main mass at NIPR and 2 polished sections (~3 cm apart with different cutting angles) were prepared. Major and minor element compositions of constituent minerals were analyzed using electron microprobe (EPMA) at University of Tokyo and trace element abundances were determined by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) at NIPR using Hoba and North Chile iron meteorites as standards.

Results and discussion: Optical microscopy of two polished sections (~1.5 x 1 cm) did not reveal any particular textures except for the weathered fractures (~0.5 mm wide). Elemental mapping by EPMA showed that the section was >95% composed of kamacite with accessory schreibersite at the weathered fractures. Taenite is rarely present as irregularly-shaped blebs (~0.01 mm wide and 0.1 mm long). The kamacite composition obtained by EPMA gave Ni=5.0-6.5 wt% and Co=0.35-0.55 wt%, showing minor chemical zoning. Schreibersite was Fe=45-53 wt% and Ni=30-38 wt%, and taenite was Fe=60-61 wt% and Ni=37-38 wt%. The LA-ICP-MS analysis using 3 lines on the section gave average Ni=6.1 wt% and Co=0.48 wt%, well matching with the EPMA result. Trace element abundances were Ir=4.2, Ga=91.9, Ge=397, Re=0.33, Os=0.33, Cu=117, Ru=7.5, Pd=3.2, Pt=8.1, Au=1.6 (all in μg/g).

Iron meteorite classification is mainly based upon the abundance of Ni, Ir and Ge. The abundance of these elements in Nagara shows that it is a IAB iron with low Ni and high Ge abundances. IAB iron meteorites are usually octahedrite, but neither sections show Widmanstatten patterns. Both sections are nearly composed of kamacite, suggesting that it is a hexahedrite. This is consistent with low Ni abundance and similar low-Ni IAB iron meteorites are Duel Hill (1873), Soledade and Yardea.

IAB iron meteorite is related to winonaite and often bears silicate inclusions. However, we did not find any obvious silicate inclusions in the sections studied.

There is a possibility that Nagara shows coarse Widmanstatten patterns beyond scales of our 1 cm sections and silicate inclusions may be located at different places. In order to clarify mineralogy on larger scales, it is necessary to study different portions of the main mass.

Keywords: Iron meteorite, kamacite, hexahedrite

